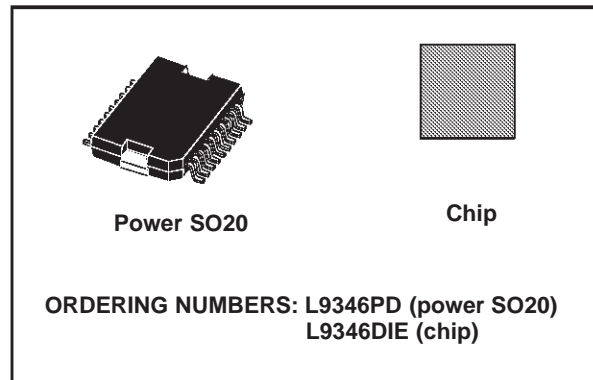


## QUAD INTELLIGENT POWER LOW SIDE SWITCH

- QUAD POWER LOW SIDE DRIVER WITH 2 x 5A AND 2 x 3A OUTPUT CURRENT CAPABILITY
- LOW  $R_{DS(ON)}$  TYPICALLY 200m $\Omega$  AND 300m $\Omega$  @  $T_j = 25^\circ\text{C}$
- INTERNAL OUTPUT CLAMPING STRUCTURES WITH  $V_{FB} = 50\text{V}$  FOR FAST INDUCTIVE LOAD CURRENT RECIRCULATION
- LIMITED OUTPUT VOLTAGE SLEW RATE FOR LOW EMI
- PROTECTED  $\mu\text{P}$  COMPATIBLE ENABLE AND INPUT
- WIDE OPERATING SUPPLY VOLTAGE RANGE 4.5V TO 32V
- REAL TIME DIAGNOSTIC FUNCTIONS:
  - OUTPUT SHORTED TO GND
  - OUTPUT SHORTED TO VSS
  - OPEN LOAD MEASURED IN ON AND OFF CONDITION
  - LOAD BYPASS DETECTION
  - OVERTEMPERATURE
- DEVICE PROTECTION FUNCTIONS:

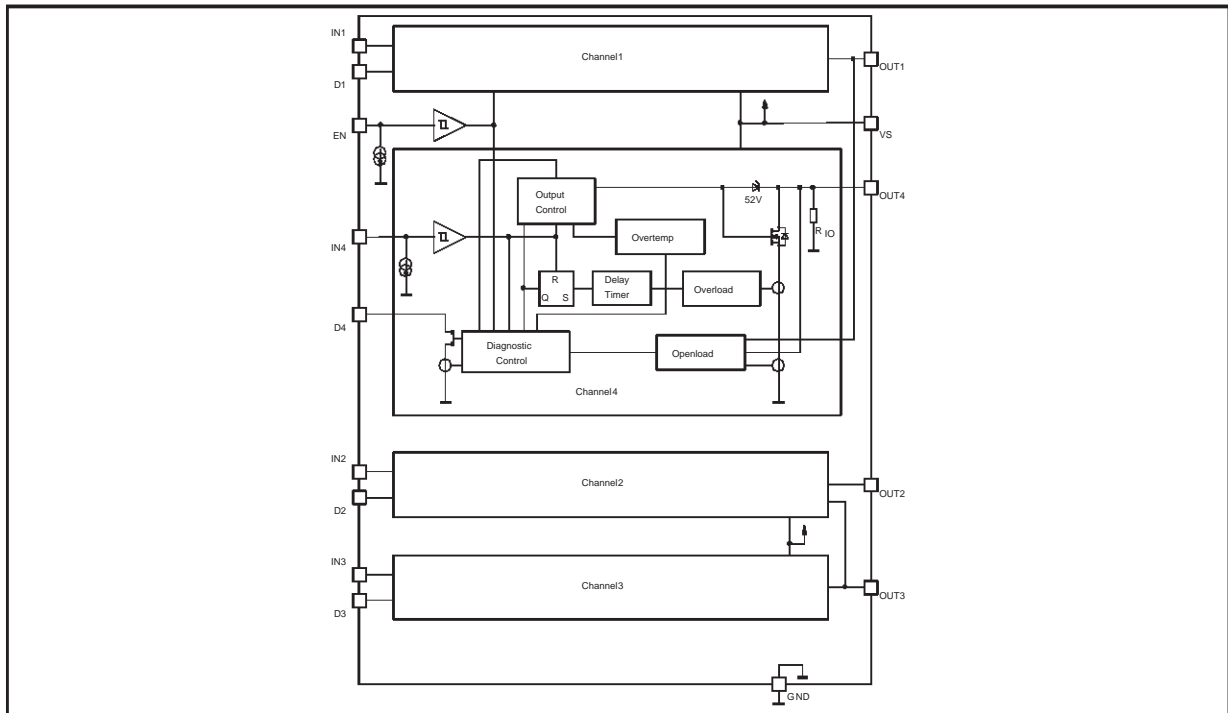


- OVERLOAD DISABLE
- REVERSE SUPPLY VOLTAGE PROTECTED VS UP TO -2V
- SELECTIVE THERMAL SHUTDOWN

### DESCRIPTION

The L9346 is a monolithic integrated quad low side driver realized in an advanced Multipow-

### BLOCK DIAGRAM



**DESCRIPTION** (continued)  
 erBCD mixed technology. The device is intended to drive valves in automotive environment.

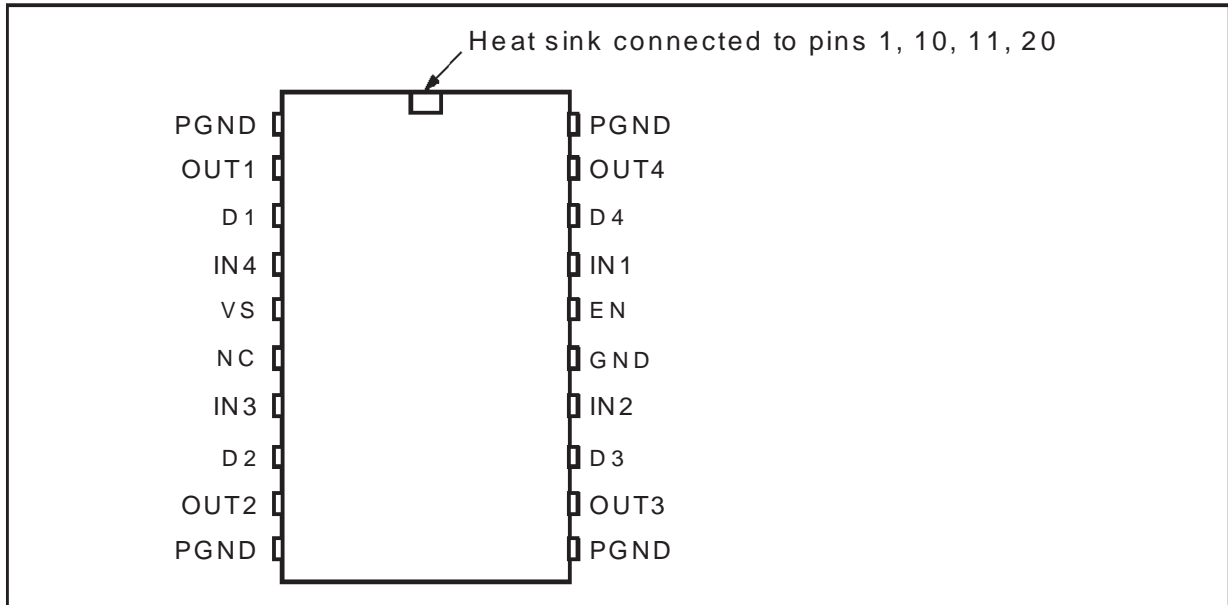
The inputs are  $\mu\text{P}$  compatible. Particular care has been taken to protect the device against failures, to avoid electromagnetic interferences and to offer extensive real time diagnostic.

**ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Conditions	Value	Unit
$V_S$	DC Supply Voltage		-2 to 32	V
$V_{SP}$	Supply Voltage Pulse (duration <200ms)		-2 to 45	V
$\left  \frac{dV_S}{dt} \right $	Supply Voltage Slope		10	V/ $\mu\text{s}$
$V_{IN, EN}$	Input Voltage	$ I  \leq 10\text{mA}$	-2 to 16	V
$V_D$	Diagnostic DC Output Voltage	$ I  \leq 50\text{mA}$	-0.3 to 16	V
$V_{ODC}$	DC Output Voltage		-0.3 to 45	V
$I_{O1, 2}$	DC Output Current Out 1, 2		5	A
$I_{O3, 4}$	DC Output Current Out 3, 4		3	A
$I_{OR1, 2}$	Reverse Output Current		-5	A
$I_{OR3, 4}$	Reverse Output Current		-3	A
$E_{O1, 2}$	Switch-off Energy for Inductive Loads	$t_{EO} = 250\mu\text{s}, ^1)$	50	mJ
$E_{O3, 4}$		$T = 5\text{ms}$	30	mJ
$\Delta V_{GND}$	GND Potential Difference	$T_j = -40 \text{ to } 150^\circ\text{C}$	$\pm 0.3$	V
$T_{jEO}$	Junction Temperature During Switch-off	$\Sigma t \leq 30 \text{ min}$	175	$^\circ\text{C}$
		$\Sigma t \leq 15 \text{ min}$	190	$^\circ\text{C}$
$T_j$	Junction Temperature		-40 to $T_{jDIS}$	$^\circ\text{C}$
$T_{stg}$	Storage Temperature		-55 to 150	$^\circ\text{C}$
$T_{jDIS}$	Thermal Disable Junction Temp. Threshold		180 to 210	$^\circ\text{C}$

The device is ESD protected, tested according to MIL883C with  $\pm 2\text{kV}$ .  
 Note <sup>1)</sup>:  $t_{EO}$  is the clamping time (see fig.1)

**PIN CONNECTION**



## THERMAL DATA

Symbol	Parameter	Value	Unit
$R_{thj-c}$	Thermal Resistance junction to case	3	K/W

## PIN FUNCTIONS

N.	Name	Function
1	GND	Power Grounded
2	Out 1	Output 1 (5A)
3	D1	Diagnostic 1
4	IN 4	Input 4
5	VS	Supply Voltage
6	NC	Not Connected
7	IN 3	Input 3
8	D2	Diagnostic 2
9	Out 2	Output 2 (5A)
10	GND	Power Ground
11	GND	Power Ground
12	Out 3	Output 3 (3A)
13	D3	Diagnostic 3
14	IN 2	Input 2
15	GND	Signal Ground
16	EN	Common Enable
17	IN 1	Input 1
18	D4	Diagnostic 4
19	Out 4	Output 4 (3A)
20	GND	Power Ground

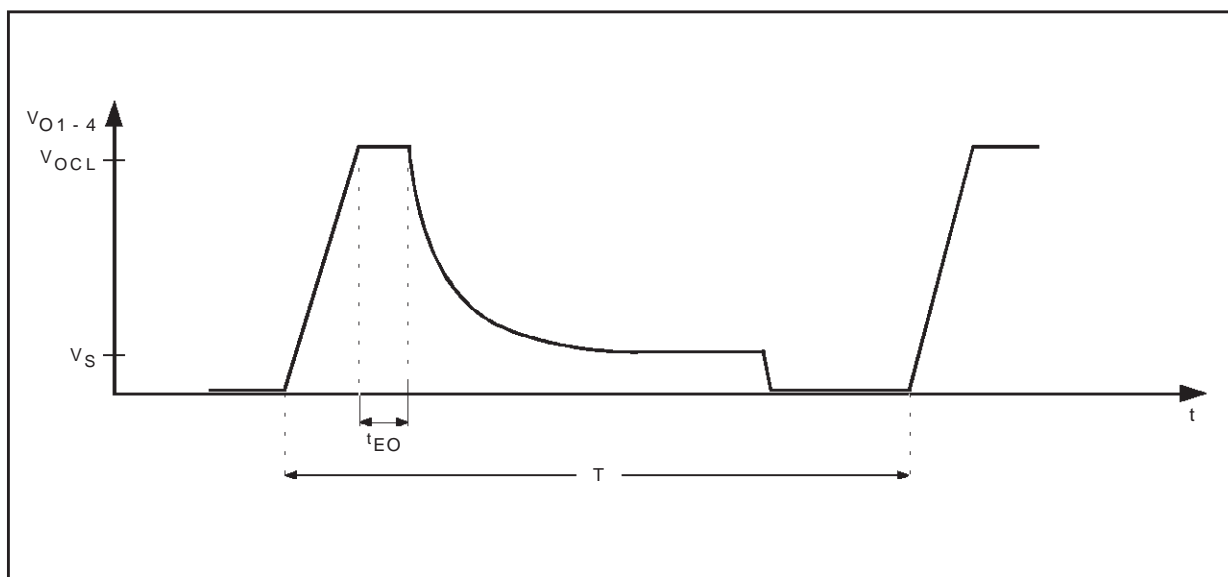
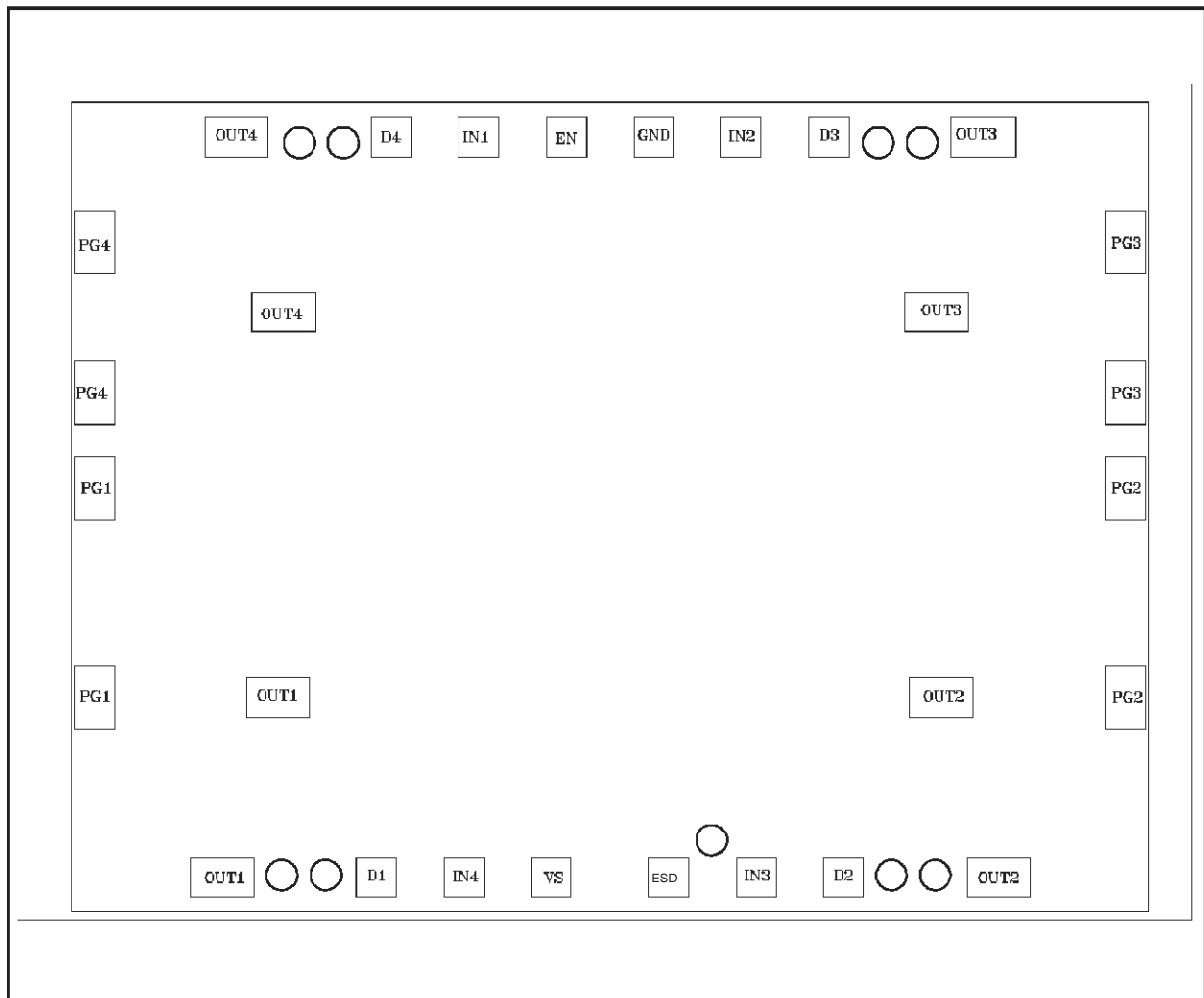
Figure 1:  $t_{EO}$  Clamping Time

Figure 2: Pad Position (Chipsize 4.95 x 3.88)



**Pad Coordinates** (Reference point X = 0, Y = 0: Center of die)

Pat opening center position					
Pad Nr.	Pad Name	Size in ( $\mu\text{m}$ )	Description	Coordinates in ( $\mu\text{m}$ )	
				X	Y
1	PG3	178 x 280	Power Ground 3	2286.5	1175
2	PG3	178 x 280	Power Ground 3	2286.5	506
3	PG2	178 x 280	Power Ground 2	2286.5	98
4	PG2	178 x 280	Power Ground 2	2286.5	-842
5	OUT2	280 x 178	Output 2 5A	1472.5	-844
6	OUT2	280 x 178	Output 2 5A	1722.5	-1644
7	D2	178 x 178	Diagnostic 2	1036	-1644
8	IN3	178 x 178	Input 3	648	-1644
9	VS	178 x 178	Supply Voltage	-260	-1644
10	IN4	178 x 178	Input 4	-648	-1644
11	D1	178 x 178	Diagnostic 1	-1036	-1644
12	OUT1	280 x 178	Output 1 5A	-1722.5	-1644
13	OUT1	280 x 178	Output 1 5A	-1472.5	-844
14	PG1	178 x 178	Power Ground 1	-2286	-842
15	PG1	178 x 178	Power Ground 1	-2286	98
16	PG4	178 x 178	Power Ground 4	-2286	506
17	PG4	178 x 178	Power Ground 4	-2286	1175
18	OUT4	280 x 178	Output 4 3A	-1448	865
19	OUT4	280 x 178	Output 4 3A	-1656	1644
20	D4	178 x 178	Diagnostic 4	-970	1644
21	IN1	178 x 178	Input 1	-582	1644
22	EN	178 x 178	Common Enable	-194	1644
23	GND	178 x 178	Signal Ground	194	1644
24	IN2	178 x 178	Input 2	582	1644
25	D3	178 x 178	Diagnostic 3	970	1644
26	OUT3	280 x 178	Output 3 3A	1656.5	1644
27	OUT3	280 x 178	Output 3 3A	1448.5	865
	<b>Test pad</b>	<b>Size</b>		<b>X</b>	<b>Y</b>
	Gate 2	d = 102		1447	-1612
	VTERM2	d = 102		1260	-1600
	IOLRED	d = 102		449.5	-1455.5
	ESD	178 x 178		260	-1644
	VTERM1	d = 102		-1260	-1600
	GATE1	d = 102		-1447	-1612
	GATE4	d = 102		-1381	1600
	VTERM4	d = 102		-1194.5	1600
	VTERM3	d = 102		1194.5	1600
	GATE3	d = 102		1381	1600

**ELECTRICAL CHARACTERISTICS (Operating Range)**

The electrical characteristics are valid within the below defined operating range, unless otherwise specified.)

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
V <sub>S</sub>	Board Supply Voltage		4.5	12	32	V
T <sub>j1</sub>	Junction Temperature		-40		150	°C
T <sub>j2</sub>	Junction Temperature	Σt ≤ 15min <sup>2)</sup> over life time	150		T <sub>JDIS</sub>	°C

NOTE:

<sup>2)</sup> Parameters guaranteed by correlation

**ELECTRICAL CHARACTERISTICS** (V<sub>S</sub> = 4.5 to 32V; -40°C ≤ T<sub>j1</sub> ≤ 150°C < T<sub>j2</sub> ≤ T<sub>JDIS</sub>, unless otherwise specified.)

Symbol	Parameter	Test Condition	Value T <sub>j1</sub>			Value T <sub>j2</sub>		Unit
			Min.	Typ.	Max.	Min.	Max.	
<b>Supply</b>								
I <sub>VS OFF</sub>	DC Supply Current Off	EN = 1.0V		5	10			mA
I <sub>VS ON</sub>	DC Supply Current On	V <sub>S</sub> ≤ 14V; V <sub>IN</sub> , V <sub>EN</sub> = 2V		8				mA
<b>Diagnostic Outputs D 1 - D 4</b>								
V <sub>DL</sub>	Diagnostic Output Low Voltage	I <sub>D</sub> ≤ 3mA		0.65	1.0		1.5	V
I <sub>DLE</sub>	Diagnostic Output Leakage Current	V <sub>D</sub> = 14V <sup>3)</sup>		0.1	2		20	μA
<b>Outputs Out 1 - Out 4</b>								
V <sub>OUV 1-4</sub>	Open Load Voltage Threshold	V <sub>IN</sub> = 1V	0.525 x V <sub>S</sub>	0.55 x V <sub>S</sub>	0.575 x V <sub>S</sub>	0.5 x V <sub>S</sub>	0.65 x V <sub>S</sub>	V
V <sub>OUV hys 1-4</sub>	Hysteresis			0.003 x V <sub>S</sub>				V
ΔV <sub>OUV 1-4, 2-3, 4-1, 3-2</sub>	Open Load Difference Voltage Threshold	V <sub>IN1,4/2,3</sub> = 1V, 4.5V ≤ V <sub>OC</sub> ≤ 16V, 4.5V ≤ V <sub>S</sub> ≤ 16V, V <sub>OC</sub> = output voltage of other channel	V <sub>OC</sub> - 1.0V	V <sub>OC</sub> - 1.25V	V <sub>OC</sub> - 1.5V	V <sub>OC</sub> - 0.8V	V <sub>OC</sub> - 1.7V	V
V <sub>OUV hys 1-4, 2-3, 4-1, 3-2</sub>	Open Load Hysteresis			40				mV
I <sub>OUC 1, 2, 3, 4</sub>	Open Load Current Threshold	V <sub>EN</sub> = V <sub>IN</sub> = 2V; V <sub>S</sub> = 6.5 to 16V	160	320	480		580	mA
I <sub>OOC 1, 2</sub>	Over Load Current Threshold	V <sub>S</sub> > 6.5V; V <sub>OUT</sub> = 32V	5	10		4		A
I <sub>OOC 3, 4</sub>			3	6		2.4		A
V <sub>OCL</sub>	Output Voltage During Clamping	I <sub>OCL</sub> ≥ 200mA	45	52	60			V
S <sub>ON,OFF</sub>	Output (fall, rise) slew rate	<sup>4)</sup> I <sub>OUC</sub> ≤ I <sub>O</sub> ≤ I <sub>OOC</sub>	400	1500	2850	200	3500	V/mA
R <sub>IO</sub>	Internal Output Pull Down Resistor	V <sub>EN</sub> = 1V	10	20	40		50	KΩ
R <sub>DSON 1, 2</sub>	Output On Resistance	T <sub>j</sub> = 25°C T <sub>j</sub> = 150°C V <sub>S</sub> > 9.5V, I <sub>O1,2</sub> = 2A		200	300 500			mΩ
R <sub>DSON 3, 4</sub>		T <sub>j</sub> = 25°C T <sub>j</sub> = 150°C; I <sub>O3,4</sub> = 1.3A		300	450 750			mΩ

NOTE:

<sup>2)</sup> Parameters guaranteed by correlation

<sup>3)</sup> The diagnostic output is short circuit protected up to V<sub>D</sub> = 16V

<sup>4)</sup> V<sub>S</sub> = 9 to 16V


## ELECTRICAL CHARACTERISTICS (continued)

Symbol	Parameter	Test Condition	Value T <sub>j1</sub>			Value T <sub>j2</sub>		Unit
			Min.	Typ.	Max.	Min.	Max.	
Inputs IN1-4, EN								
V <sub>IN,EN L</sub>	Logic Input/Enable Low Voltage		-0.3		1		0.8	V
V <sub>IN,EN H</sub>	Logic Input/Enable High Voltage	IN, EN	2.0		16			V
V <sub>EN,IN hys</sub>	Logic Input Hysteresis		0.2	0.4	0.8			V
I <sub>IN</sub>	Input Sink Current	V <sub>IN</sub> = 2 to 12V <sup>5)</sup>	10	30	60		240	μA
I <sub>EN</sub>	Enable Sink Current		10	20	40		240	μA
Timing								
t <sub>D ON</sub>	Output Delay ON Time	<sup>6)</sup> Fig. 7		4	25			μs
t <sub>D OFF</sub>	Output Delay OFF Time	<sup>6)</sup> Fig. 7	5	15	30			μs
t <sub>DH-L, Diag</sub>	Diag. Delay Output OFF Time	<sup>6)</sup> Fig. 6	8		65		90	μs
t <sub>D IOU</sub>	Diagnostic Open Load Delay Time	V <sub>s</sub> = 9 to 16V, Fig 8 I <sub>o</sub> ≤ I <sub>oUC</sub>		8	50			μs
t <sub>DOL</sub>	Diagnostic Overload Delay Switch-OFF Time	V <sub>s</sub> = 9 to 16V, Fig 8 I <sub>o</sub> > I <sub>oUC</sub>	50	160	300			μs
t <sub>D EN ON</sub>	Enable ON Time	<sup>6)</sup> Fig. 7		4	25			μs
t <sub>D EN OFF</sub>	Enable OFF Time	<sup>6)</sup> Fig. 7		4	25			μs

NOTE:

<sup>5)</sup> Open pins (EN, IN) are detected as low<sup>6)</sup> V<sub>s</sub> = 9 to 16V ∧ I<sub>oUC</sub> ≤ I<sub>o</sub> ≤ I<sub>oOC</sub>

## DIAGNOSTIC TABLE

CONDITIONS		EN	IN	OUT	DIAG.
Normal Function		L	X	off	L
		H	L	off	L
		H	H	on <sup>7)</sup>	H
GND short	V <sub>Otyp</sub> < 0.55V <sub>s</sub>	L	X	off	H
Load bypass	ΔV <sub>O1-4/2-3</sub> ≥ 1.25V	H	L	off	H
Open Load	I <sub>o1,2,3,4typ</sub> < 320mA	H	H	on <sup>7)</sup>	L
T <sub>jtyp</sub> ≥ 190°C Overtemperature <sup>8)</sup>		X	X	off	L
Over Load	I <sub>omin 1,3</sub> > 5A I <sub>omin 2,4</sub> > 3A	H	H	off	L
Reset and Overtemperature Latch		X		DC don't care	DC don't care

NOTE:

<sup>7)</sup> For V<sub>s</sub> = 4.5 to 6.5V, I<sub>o</sub> ≤ 2A, the diag. table is valid<sup>8)</sup> If one diag. status shows the overtemperature, recognition, in parallel this output will be switched OFF internally.The corresponding channel should be switched OFF additionally by its input signal, otherwise the overload latch will be set after t<sub>DOL</sub> is passed. This behaviour is related to the overdrop sensing which is used as over load recognition.

The overtemperature is latched (DIAG = L) until the level of the IN signal changes to low.

**CIRCUIT DESCRIPTION**

The L9346 is a quad low side driver for inductive loads like valves in automotive environment. The internal pull down current sources at the ENABLE and INPUT pins assure in case of open input conditions that the device is switched off. An output voltage slope limitation for  $du/dt$  is implemented to reduce the EMI. An integrated active flyback voltage limitation clamps the output voltage during the flyback phase to 50 V.

Each driver is protected against short circuit at  $V_{OUT} < 32V$  and thermal overload. In short circuit condition the output will be disabled after a short delay time  $t_{DOL}$ . The thermal disable for  $T_J > 180^{\circ}C$  of the output will be reset if the junction temperature decreases about  $20^{\circ}C$  below the disable threshold temperature.

The overtemperature information is stored until  $IN = L$ .

For the real time error diagnosis the voltage and the current of the outputs are compared with internal fixed values  $V_{OVV}$  for OFF and  $I_{OUC}$  for ON conditions to recognize open load ( $R_L \geq 20 K\Omega$ ,  $R_L > 38\Omega$ ) in OFF and ON conditions.

Also the output voltages  $V_{O1} - 4$  are compared to each other output in OFF condition with a fixed

offset of  $\Delta V_{OVV}$  to recognize load bypasses. To suppress the  $\Delta V_{OVV}$  diagnoses during the flyback phases of the compared output, the  $\Delta V_{OVV}$  diagnostic includes a latch function.

Reaching the flyback clamping voltage  $V_{OCL}$  the diagnostic signal is reseted by a latch. To activate again this kind of diagnostic a low signal at the correspondent INPUT or the ENABLE pin must be applied (see also Fig.3). The outputs 1 and 4 are compared for  $\Delta V_{OVV}$  and also outputs 2 and 3 are compared.

The diagnostic output level in connection with different ENABLE and INPUT conditions allows to recognize different fail states, like overtemp, short to  $V_{SS}$ , short to GND, bypass to GND and disconnected load (see diagnostic table).

The diagnostic output is protected against short circuit. Exceeding the over load current threshold  $I_{OOC}$ , the output current will be limited internally during the diagnostic overload delay switch-off time  $t_{DOL}$ .

The device complies the ISO pulses imposed to the supply voltage of the valves without any failures of the functionality.

**Figure 3. Diagnostic Overload Delay Time**

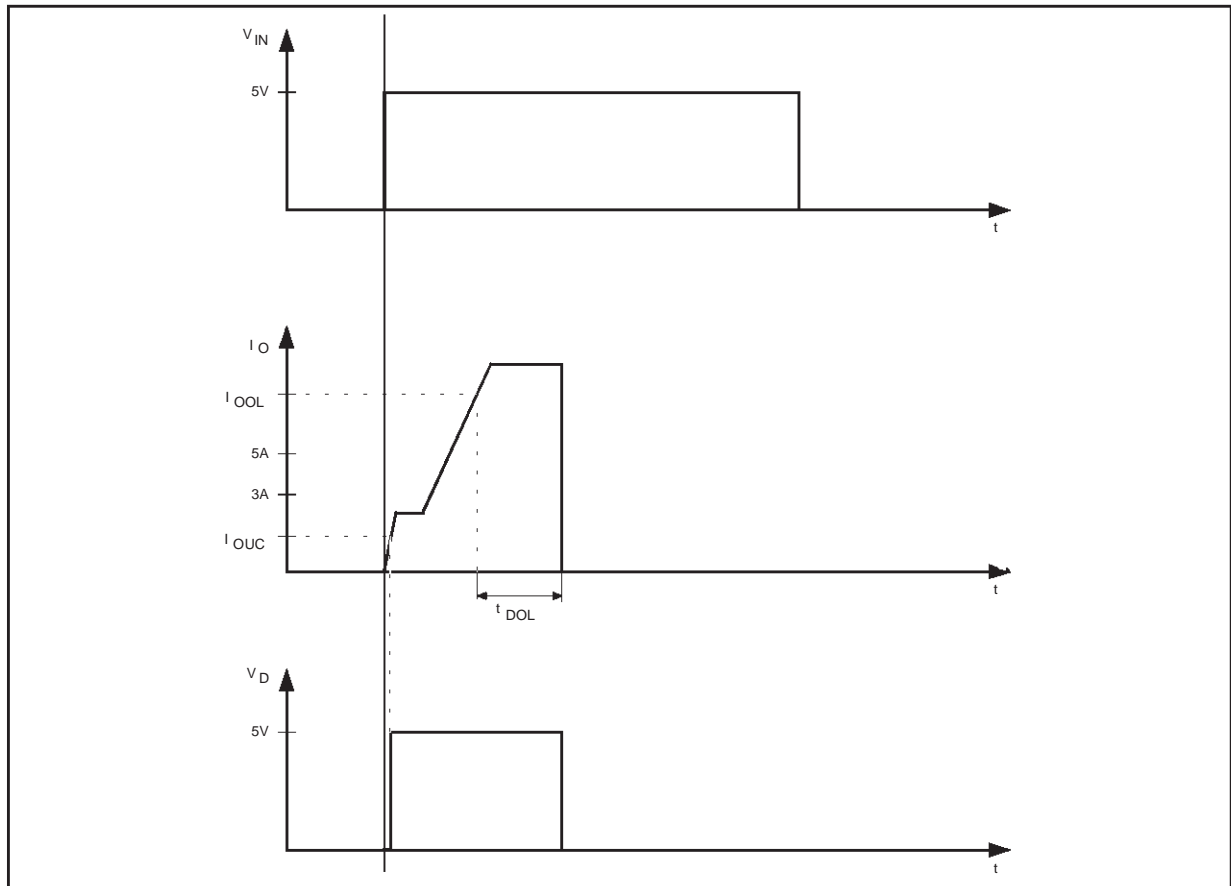




Figure 4. OUTPUT SLOPE (Resistive load for testing)

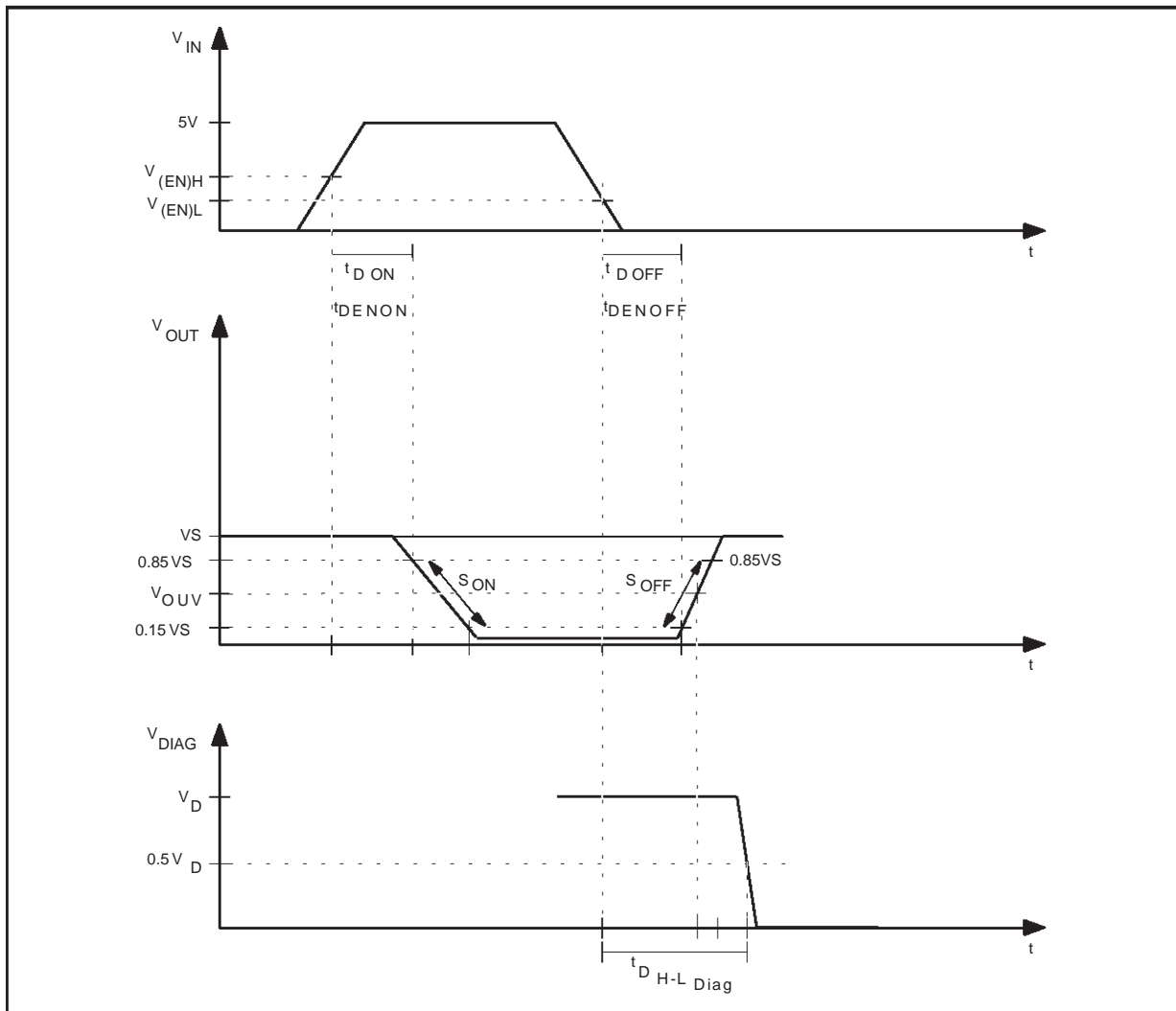
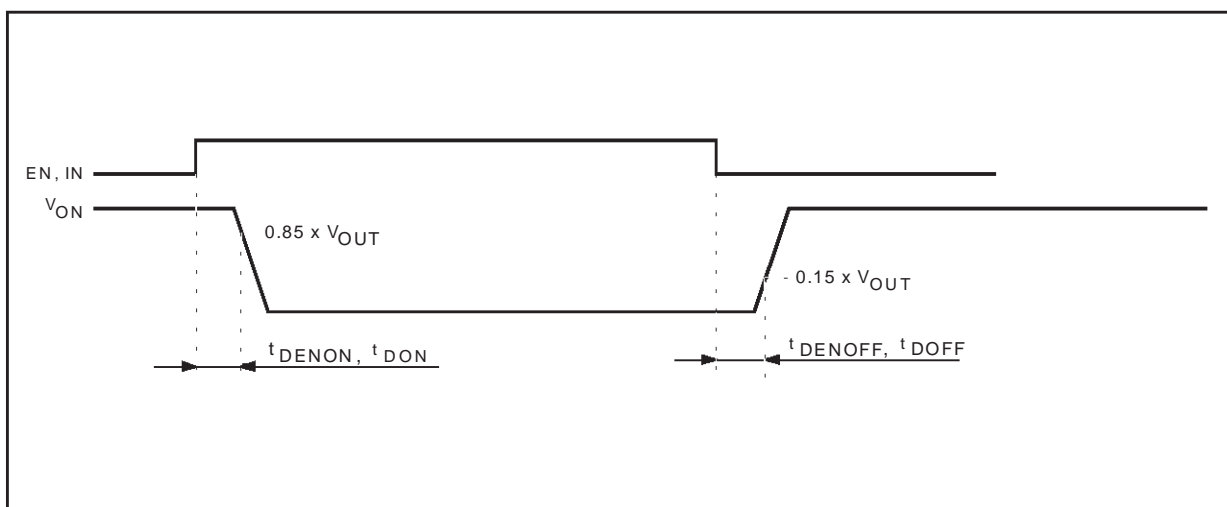
Figure 5. TIMING ( $t_{DENON}$ ,  $t_{DON}$ ,  $t_{DENOFF}$ ,  $t_{DOFF}$ )

Figure 6. TIMING ( $t_{DOL}$ ,  $t_{DIOU}$ )

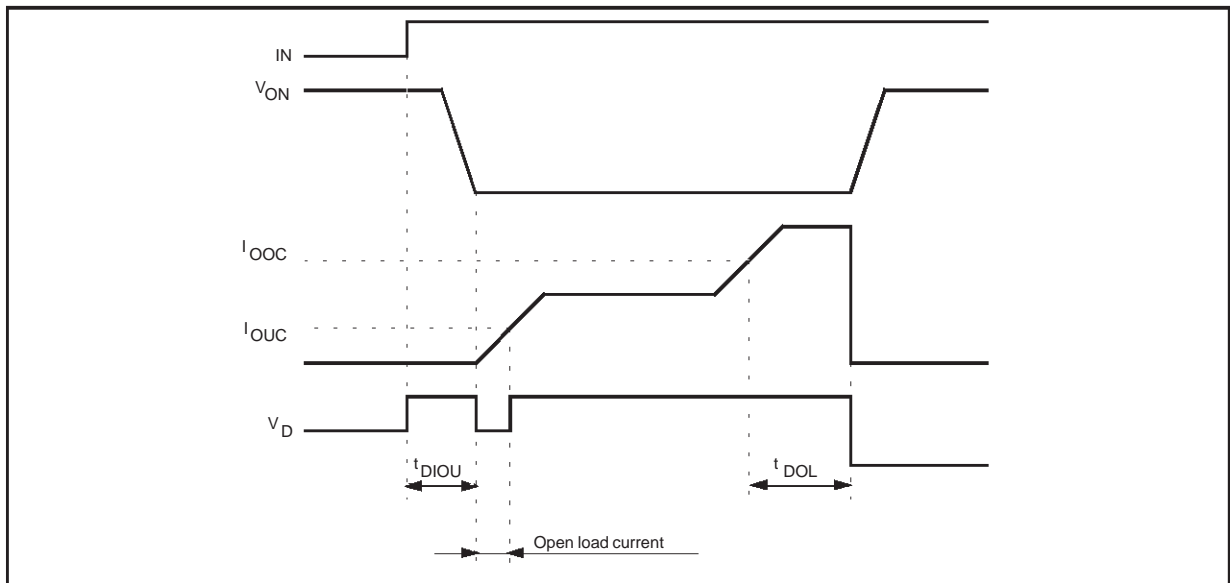


Figure 7. BLOCK DIAGRAM - Open Load Voltage Detection

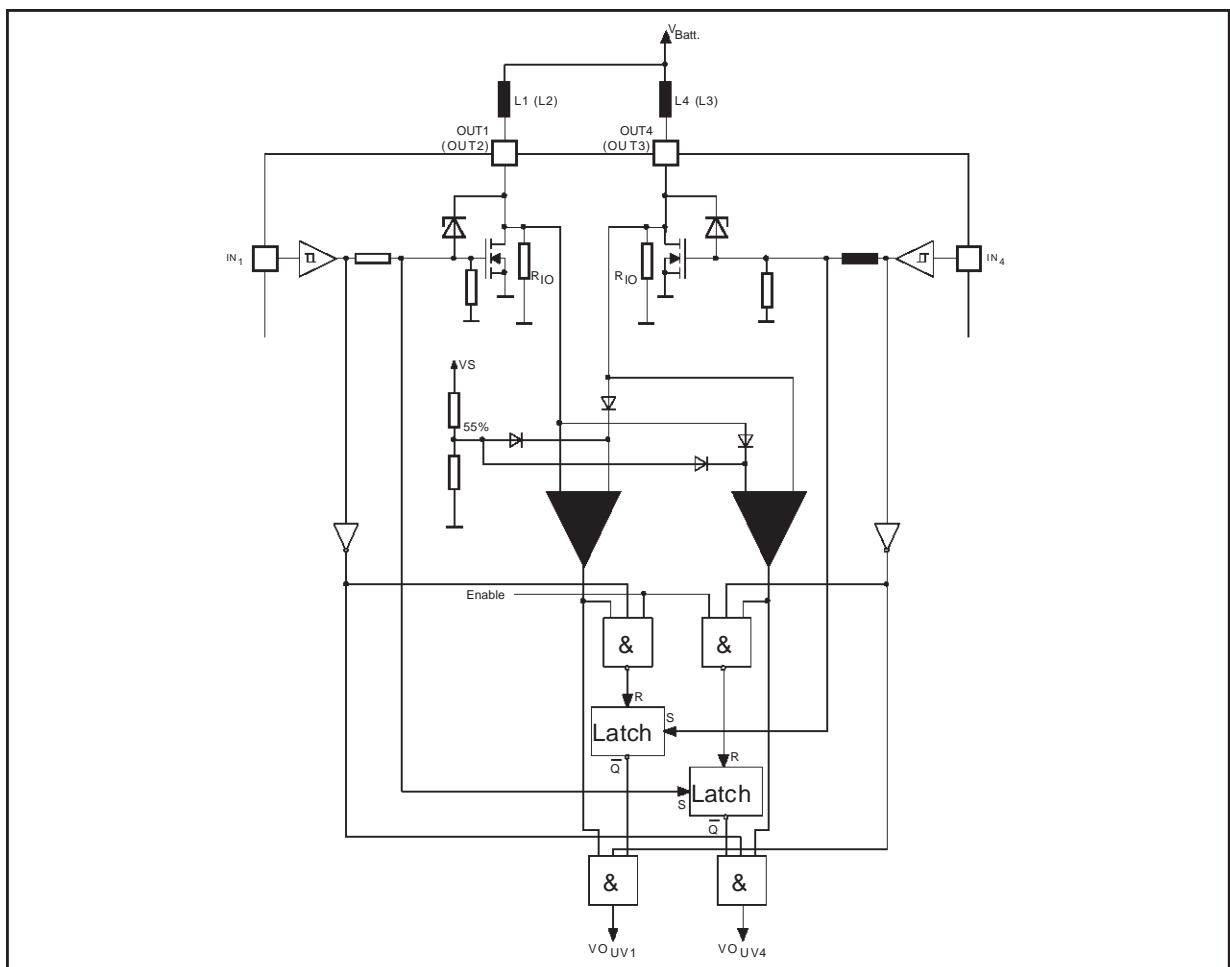


Figure 8. Logic Diagram

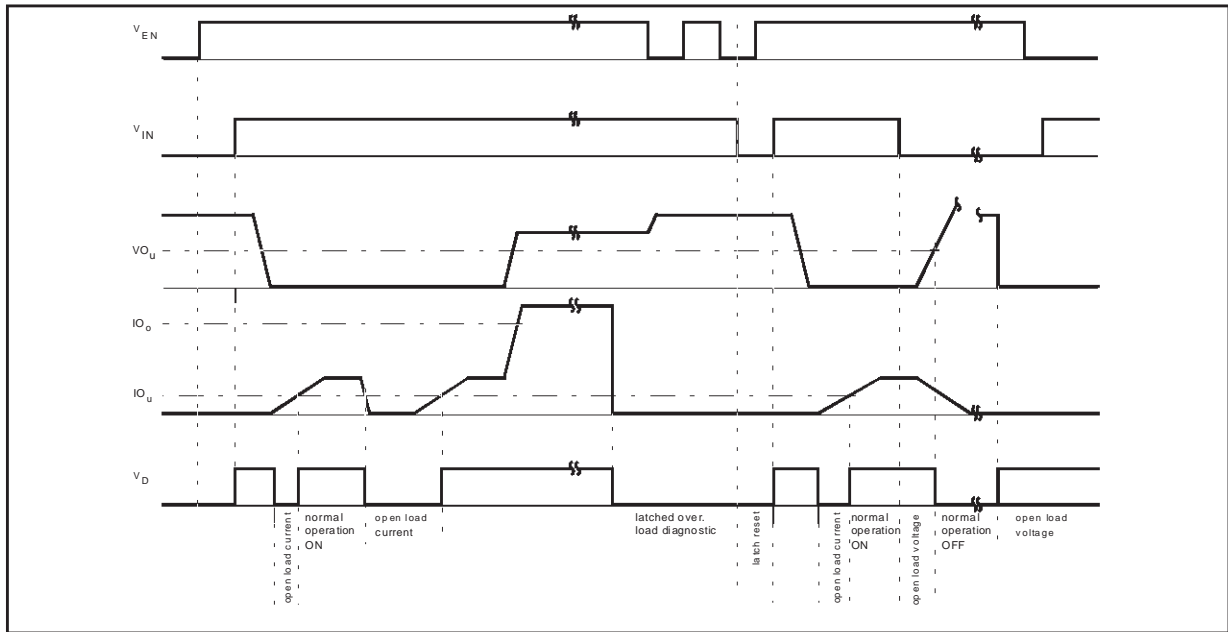
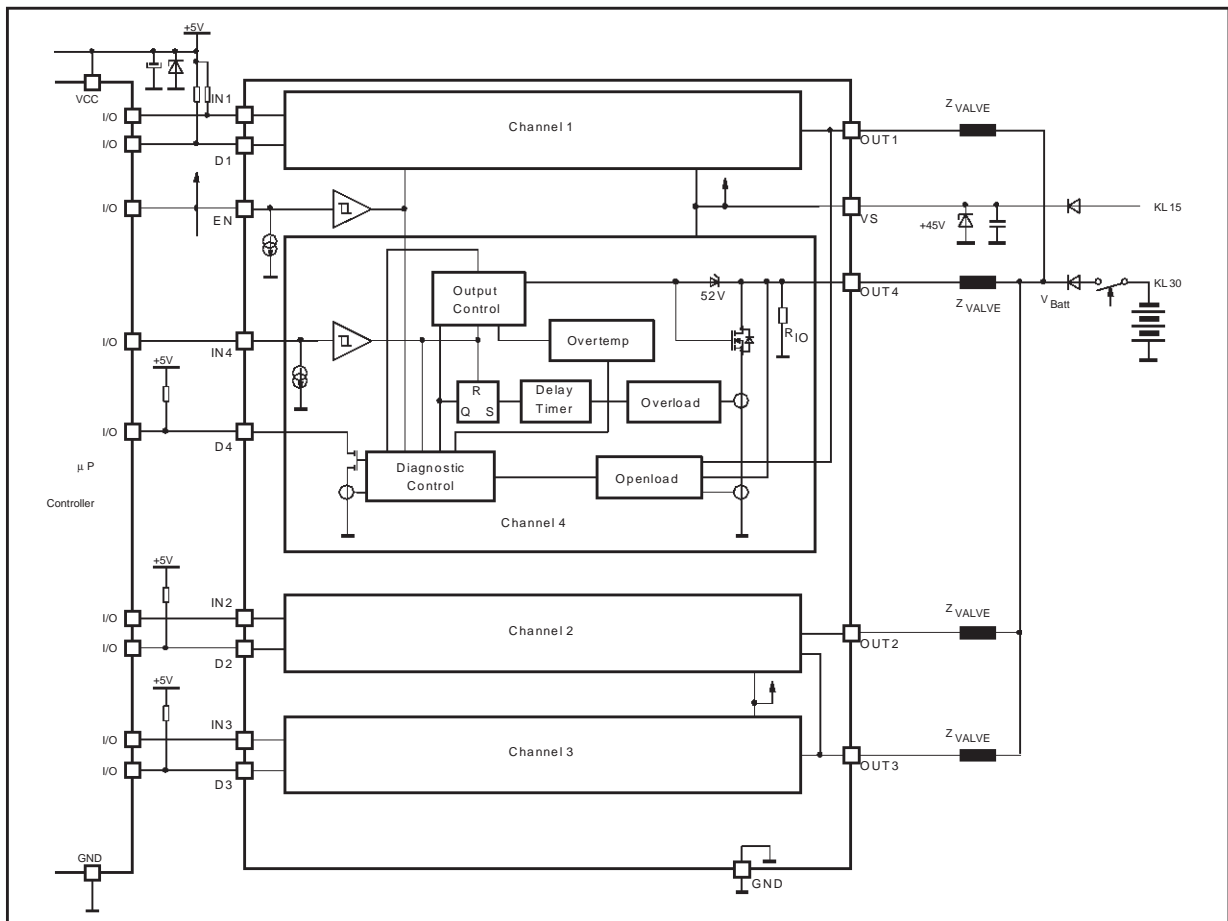


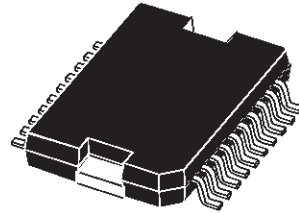
Figure 9. Application Circuit Diagram



DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			3.6			0.142
a1	0.1		0.3	0.004		0.012
a2			3.3			0.130
a3	0		0.1	0.000		0.004
b	0.4		0.53	0.016		0.021
c	0.23		0.32	0.009		0.013
D (1)	15.8		16	0.622		0.630
D1	9.4		9.8	0.370		0.386
E	13.9		14.5	0.547		0.570
e		1.27			0.050	
e3		11.43			0.450	
E1 (1)	10.9		11.1	0.429		0.437
E2			2.9			0.114
E3	5.8		6.2	0.228		0.244
G	0		0.1	0.000		0.004
H	15.5		15.9	0.610		0.626
h			1.1			0.043
L	0.8		1.1	0.031		0.043
N	10° (max.)					
S	8° (max.)					
T		10			0.394	

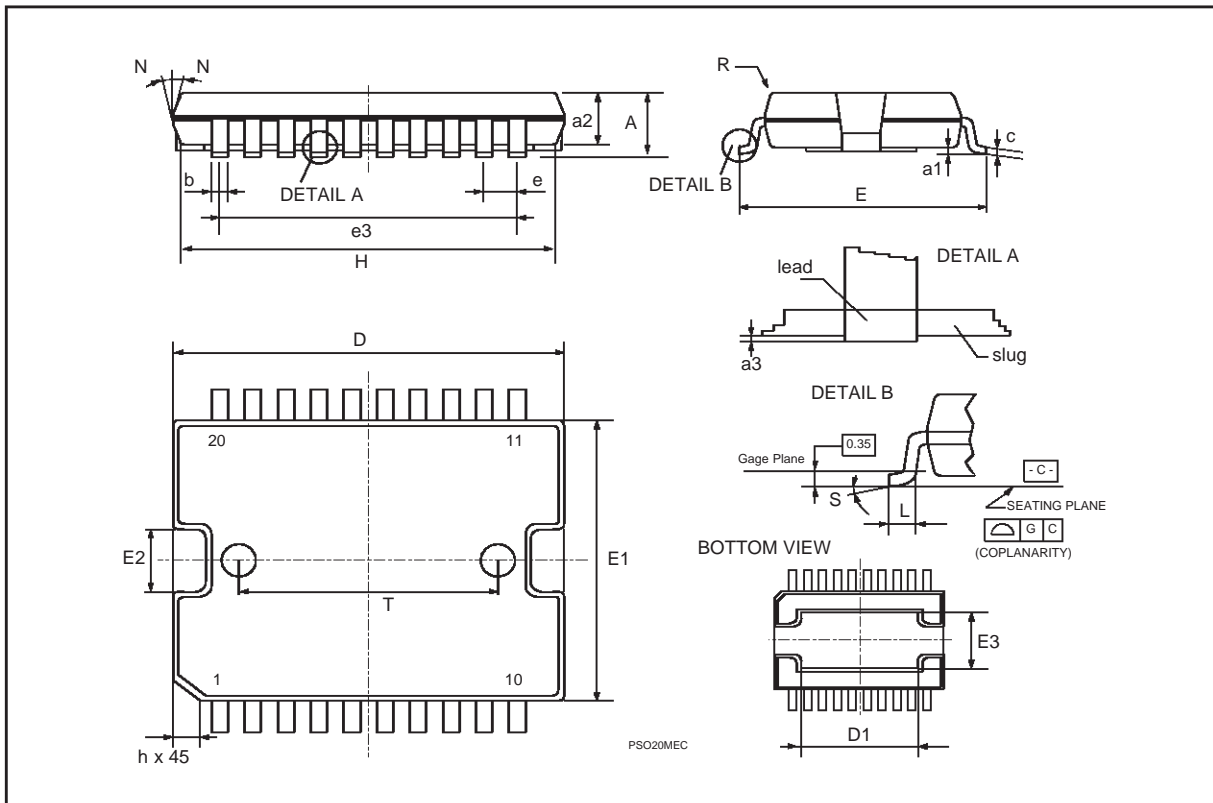
(1) "D and F" do not include mold flash or protrusions.  
 - Mold flash or protrusions shall not exceed 0.15 mm (0.006").  
 - Critical dimensions: "E", "G" and "a3"

**OUTLINE AND MECHANICAL DATA**



**JEDEC MO-166**

**PowerSO20**



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